FINE-GRAIN DEVELOPMENT

with particular reference to

PROMICROL

MAY & BAKER LTD

FOURTH EDITION

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(*Incorporated in England*)

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Fine-grain Development

THE CAUSE OF GRAININESS

In normal photographic procedure, development of the exposed sensitive emulsion causes reduction of its silver bromide crystals with the formation of particles of black metallic silver, which comprise the visible negative image. These particles are so small that they are invisible except under a high-power microscope, and individually they are not a cause of trouble to the photographer.

There is, however, a tendency for the silver particles to form aggregates as development proceeds. These aggregates are much larger than the crystals originally in the emulsion, and their presence might become obvious when the negative is substantially enlarged. The print thus produced may show areas of unpleasant, mottled appearance.

Various terms are used in discussing this phenomenon, and it is important to distinguish between them.

Grain size refers to the size of an individual particle of silver, usually between 0·001 and 0·005 mm.; such particles are far too small to be seen by the unaided eye, and even under a magnification of 100 diameters, many would remain invisible. This term should, therefore, generally be avoided when discussing the granular effect of a developed photographic image.

Graininess is the term used to express the visible granular effect caused by density irregularities over an area which should be uniform in tone; the object of "fine-grain" development technique is primarily to diminish or eliminate this non-uniformity.

Granularity is used in more technical discussions, in which micro-density determinations and similar measurements are involved. It differs from "graininess"

chiefly in viewpoint – "graininess" relates to the subjective aspect, being concerned with what the eye can see, while "granularity" refers to the objective aspect which can be measured with instruments. The precise relation between graininess and granularity has been the subject of many investigations.

THE PREVENTION OF GRAININESS

It is obvious that graininess cannot be suppressed entirely, so long as metallic silver particles form the negative image; however, by taking suitable precautions, it can be greatly reduced. This is important because the popularity of the so-called "miniature" camera has led to the production of negatives from which enlargements are normally required.

The most important factors in ensuring low graininess in negatives, and diminishing its effect in the resulting prints, are:

Choice of the right film. It is generally true that the more sensitive a film is to light, the more pronounced will be its graininess after development. If enlargements of twenty diameters are required, a medium-speed, fine-grain film should normally be selected.

Choice of the right exposure. Over-exposure, in general, tends to increase the graininess of a negative, and the exposure should therefore be the minimum compatible with adequate rendering of important shadow detail.

Choice of the right negative developer. It has long been known that the graininess produced on a negative depends partly upon the composition of the developer employed and the conditions under which it is used. This aspect of the subject is discussed at greater length in the next section.

Choice of the correct development time. Over-development is a very frequent cause of pronounced graininess, and it is therefore essential to ensure that the conditions used will give satisfactory negatives with development time cut to a minimum. Since the gamma to which a negative is developed, and the rate of agitation, are factors which vary between individuals, the development times quoted in any publication can do no more than suggest a basis for personal experiment.

Choice of enlarging conditions. A fine-grained negative does not necessarily ensure a print free from graininess; there are three important ways whereby the graininess of a negative can be controlled during the enlargement and neglect of these will tend to emphasize the graininess.

Condenser-type enlargers reproduce the graininess of the negative, but diffusion tends to diminish the effect.

Since the higher the contrast of a print, the more obvious the graininess, it is important to use the softest grade of paper consistent with high print quality. Negatives should therefore be developed sufficiently to enable a medium or soft grade to be used. This advice is, of course, partly opposed to that given above, and clearly in practice a compromise has to be adopted, but the exact nature of the compromise is necessarily an individual matter.

A rough paper should be used, rather than a smooth or glossy surface; the roughness of the surface tends to hide the irregularities in density caused by the graininess of the image, but a glossy paper will reveal the individual clumps with remarkable clarity.

In addition to the five factors mentioned above, particular care must be taken throughout the operations to avoid mechanical abrasion, dirt and other extraneous sources of damage to the negatives; it is futile to employ the best fine-grain development technique, and then to dry the films in a dusty atmosphere.

Fine-grain technique

GENERAL CONSIDERATIONS

Much work has been done in the past twenty years with the object of producing negatives from fast emulsions which do not show objectionable graininess on enlargement. The emulsion manufacturers have made great contributions to this objective by the introduction of faster and faster emulsions without any significant increase in graininess, and the popularity of small cameras is due largely to this fact.

On development the intrinsic grain structure of the emulsion is not diminished; all that a fine-grain developer can be expected to do is to refrain from increasing the original graininess. For this reason it is usual to employ a relatively mild developing agent in a relatively mild alkaline solution. The time of development should be as short as is consistent with the production of negatives from which prints of excellent quality may be obtained.

SILVER HALIDE SOLVENTS

One valuable improvement in fine-grain technique is the use of a silver halide solvent; a suitable agent is introduced into the developer which gives it a tendency to dissolve the outer surfaces of the silver bromide crystals, thus reducing their area and the consequent graininess. Sodium sulphite is the most common substance of this type; it is of course used as a preservative in most developers, but it has a weak silver halide solvent action and many fine-grain developers contain up to 10 per cent of it.

Fine-grain developers with high sulphite concentrations are widely used for general work and in cinematographic processing; the inclusion of borax in place of sodium carbonate enables the developing agents to work at a lower alkalinity, with the result that negative images of satisfactory graininess are obtained at relatively high emulsion speeds.

Fine-Grain Developer 320 – M&B is a good example of such a product; it is used by many photographers for routine processing, but if it is desired to reduce exposures as much as possible and also to secure minimum graininess, use is made of the outstanding properties of 'Promicrol'.

More effective solvents are potassium thiocyanate, organic amines, ammonium and sodium chlorides. Formulae containing each of these are known, and perhaps the most widely used is potassium thiocyanate, which is also employed in developers for reversal processing.

From the mechanism of graininess reduction of this type of developer, it will be obvious that some loss of emulsion speed is to be expected; since some of the exposed silver bromide is removed by the developer, it is not available for development and hence cannot contribute its quota of silver to form the densities of the negative image.

SPECIAL DEVELOPING AGENTS

An alternative approach to the problem of diminishing the graininess of a negative is to use a special developing agent which is capable of producing the effect desired. The outstanding example of such an agent is *p*-phenylenediamine; this is a very weak developer, but in the presence of sodium sulphite it gives deposits of silver of minimum graininess. In fact, no other developer yet known surpasses it in this respect.

However, this developer has certain serious disadvantages which prevent it from becoming highly popular; it is such a weak developing agent that it causes a severe loss of emulsion speed, and it is usually necessary to increase the duration of the normal exposure by three, if reasonable negatives are to be obtained. In addition, the development times required are inordinately long. Finally, *p*-phenylenediamine stains the skin badly and is stated to give rise to dermatitis.

The mechanism whereby *p*-phenylenediamine produces its characteristic minimum graininess is mainly a matter of conjecture; the available evidence suggests that its action resembles that of the silver halide solvents, since the diamine

is known to possess a marked affinity for silver halide. The outstanding advantage of *p*-phenylenediamine – that of giving minimum graininess – has led to many attempts at enhancing its activity so as to increase the emulsion speed without increasing the graininess. Various substances such as glycin and phenols have been added to the developer, with some resulting increase in emulsion speed, but the loss nevertheless remains serious.

PHYSICAL DEVELOPMENT

This name is applied to a group of methods, the essential feature of which is that the silver forming the negative image is derived from silver compounds in the original developing solution, rather than from the silver bromide crystals in the emulsion. It is even possible to develop the latent image after fixation if an alkaline thiosulphate solution is used for fixing as this does not attack the latent image very readily.

Before World War II these methods had many adherents, but they give very great loss in emulsion speed, and it is also doubtful whether the reduction in graininess claimed is real.

'Promicrol'

The nearest approach to the ideal fine-grain developer

GENERAL CONSIDERATIONS

The previous discussion shows that the ideal fine-grain developer should give a graininess similar to that obtained with *p*-phenylenediamine and at the same time preserve the maximum possible emulsion speed. This ideal has not yet been attained, but 'Promicrol' is a product which approaches this ideal more nearly than any other known developer.

'Promicrol' contains a new combination of developing agents, which is the subject of British Patent No. 644,249, United States Patent No. 2,610,122; and German Patent No. 850,384 (all assigned to May & Baker Ltd) it appears to achieve its object of giving minimum graininess by a combination of the methods described on pages 8 and 9. As well as possessing some silver halide solvent properties, the special developing agents combine to give negatives the graininess of which is hardly distinguishable from that given by *p*-phenylenediamine itself, but, nevertheless, the development times with 'Promicrol' are no longer than those of most normal developers.

At the same time, the other constituents are so balanced that the effective emulsion speed given by 'Promicrol' is either substantially equal to the accepted maximum, or in excess of it. The apparent increase of speed depends upon the method used to estimate it; this point is discussed further on pages 27 and 28.

Further details of the special properties of this developer are given in the Technical Data section of this booklet. In addition, 'Promicrol' has all the other properties expected of a first-class developer – it is easy to prepare and use, it is clean-working and has a long life and it gives consistent results.

DIRECTIONS FOR PREPARING THE DEVELOPER

Each container of 'Promicrol' contains two packages; the smaller holds the developing agents and the larger the alkalis and other constituents.

To prepare the developing solution, the contents of the smaller package are added to warm water (at about 100°F or 40°C), the volume of water used being about three-quarters of the total bulk required. The suspension is shaken or stirred until most of the solid has dissolved, and the contents of the larger packet are then added.

The suspension is again shaken or stirred until all the solid has dissolved; after cooling it is diluted to the appropriate volume and is then ready for use.

The developer is best prepared in the bottle or tank in which it is to be kept; other containers of glass, china, or plastic can be used, but metal vessels other than high-quality stainless steel should be avoided. The developer may be stored in well-closed bottles (preferably using a rubber bung), away from direct sunlight and preferably in the dark.

DIRECTIONS FOR USING THE DEVELOPER

To make full use of the exceptional advantages of 'Promicrol', it is essential to standardize the conditions of development; in particular, the temperature, degree of agitation and time of development must be accurately controlled, since under-development will give negatives which are too soft and require a hard paper for enlargement. Over-development will lead to increased negative graininess and thus defeat the purposes of the developer.

Temperature. The recommended temperature for processing is 68°F (20°C), and most of the sensitometric work, the results of which are discussed on pages 29 and 31, was carried out at this temperature. The best results with 'Promicrol' will be obtained at temperatures between 65° and 70°F (18° and 21°C), but it can be used between 59° and 75°F (15° and 24°C) if necessary. The use of 'Promicrol' without modification at temperatures above 75°F (24°C) is not recommended (*see page* 31).

Where prevailing conditions make development at higher temperatures unavoidable, anhydrous sodium sulphate can be added to the solution to reduce swelling of the gelatin. Full details of the procedure to be adopted are given on page 24.

Agitation. Consistent results will be obtained only if a consistent form of agitation is employed; the results quoted in the tables on pages 15, 16 and 17 for roll and miniature films were determined using moderate agitation in a spiral tank. By "moderate agitation" is meant complete mixing of the solution at intervals of one minute throughout the development time. For sheet films and plates, which were developed in plate tanks, the agitation was intermittent; "intermittent agitation" consists of lifting the hangers out of the tank, and replacing them rapidly, three times, the whole operation being repeated at intervals of one minute throughout the development time. It is, of course, not necessary to use these particular types of agitation, but it is essential to adopt one method and to use it consistently.

Development time. Since the contrast of a negative depends upon the extent to which it has been developed, it is often convenient to have a function which can express this extent of development. The function widely used for this purpose is "gamma", and the simplest way to express its meaning is to define it as the ratio of the density range of the negative to the brightness range of the subject.

Gamma increases with development time, and in general negatives of relatively high gamma should be printed on soft bromide papers; negatives of relatively low gamma require hard papers for satisfactory printing. If negatives are intended to be printed by enlargement, it is usual to adjust the development time to produce a gamma value about 0·7.

For most photographic purposes, however, it is neither necessary nor convenient to measure the gamma to which negatives are developed, but it is important to use conditions which will yield a reasonably constant gamma. It is for this reason that the need for a consistent processing technique has been emphasized above.

Development times in minutes for three different gammas are given in the tables on pages 14 to 18; they have been determined by using fresh 'Promicrol' at 68°F (20°C), with the agitation methods described above. Individual differences in technique may require times slightly different from those quoted; in particular, if continuous agitation is given, the times should be reduced by about 30 per cent.

It is recommended that the following development times for a gamma of 0·7 should be used, unless there is a reason for selecting a different gamma.

SPECIAL NOTE

The fog level given by 'Promicrol' is unusually low and the addition of an antifogging agent is entirely unnecessary. Moreover, it has been shown that some proprietary antifogging agents greatly reduce the activity of the developer and no such addition to 'Promicrol' is recommended.

Plates		Gamma		
		0·6	0·7	0·8
Ferrania	Super Rapide 32°	7½	9	11
Gevaert	Panchromosa	6	7½	9½
	Superchrome	7	8½	10
Ilford	F.P.4	8	10	13
	H.P.S	9½	12	15
	H.P.3	8½	10	12
	Press Ortho Series 2	11	14	18
	Selochrome	10	12	15
	Soft Gradation Pan	11	13	16
	Special Rapid	5	7	10
	Special Rapid Pan	6	8	11
	Zenith	5	7	10
Kodak (Great Britain)	O. 800	7	9	11
	P.1200	9	12	19
	P.1500	7	9	11
	P.2000	15	–	–

Roll Films		Gamma		
		0·6	0·7	0·8
Adox	R 14	4	8	12
	R 17	8	12	18
	R 18	4½	6	7½
	R 21 P	5	6	8
	R 21 PM	5½	7	10
	R 23	7	8½	10½
Agfa	Isopan F	4	5½	7½
	Isopan ISS	4	5½	7
	Isopan Ultra	5	7	9½
Ansco	Plenachrome	6	8	10
	Super Press	15	20	26
	Supreme	11	15	23
Bauchet	Hyperpan Special Rapid	7	9	11½
Crumiere	Aviapan	10½	12½	14½
Dalco	Mezzochrome	13	16	22
	Mezzopan	12½	16	19
	Spectropan	13	17	22
Dufay	Ortho	8	10	12
	Pan	11½	17	—
Ferrania	Superpanchro 32°	7	8½	10
	Superpanchro 28°	12	14	17
	Ultrachromatica	6½	8½	10½
Fuji	Neopan SS	10	16	30
Gevaert	Gevachrome	6	8	10½
	Gevapan 27	6½	9	12
	Gevapan 30	6	8½	14
	Gevapan 33	8½	11	14
Hauff	Pancola	4	5½	8
	Pancola Super	8½	11	14
	Ulcroma	13	16	24
Ilford	F.P.3	4	6	8
	H.P.3	4½	6	8
	H.P.S	5½	7	9
	Selochrome	7½	10	13

Roll Films (*contd.*)		Gamma		
		0·6	0·7	0·8
Kodak (Australia)	Super XX	5½	7½	10
	Verichrome	7	10	14
Kodak (Canada)	Plus X	12	14	17
	Super XX	10	11½	14
	Tri-X	5½	7	9½
	Verichrome	8½	12	18
Kodak (Eastman Kodak)	Plus X	8	12	16
	Super XX	10	13	15
	Tri-X	6½	9	12
	Verichrome	8½	11	14
Kodak (France)	Panatomic X	10	13	15½
	Plus X	7	10½	14½
	Super XX	5½	8	10½
	Verichrome	10	12	14
Kodak (Great Britain)	Panatomic X	7	8	10
	Plus X	7	10	14
	Super XX	11	18	—
	Tri-X	5½	8	12½
	Verichrome	4	6½	9
Konishiroku	Sakura Konipan USS	14	—	—
Kranz	Pan 21	4½	6	8
	Pan Super 23	5	7	10
Lumiere	Altipan	12½	16	23
	Lumipan	16	23	27
Merkur	Tonapan	15	23	27
Mimosa	Panchroma	11	13	16
Perutz	Peromnia	4½	6½	8½
	Perpantic	5½	7½	10
Tensi	Beta 30°	10	11½	14
Turaphot	Turapan	10	12½	15

Miniature Films		Gamma		
		0·6	0·7	0·8
Adox	KB 14	4	8	12
	KB 17	8	12	18
	KB 21	5	6	8
Agfa	Isopan F	4½	6½	9½
	Isopan FF	6	7½	9½
	Isopan ISS	4½	6½	8½
	Isopan Ultra	5	6	8
Ansco	Supreme	8	10	12½
	Ultraspeed	10	12½	14½
Du Pont (Defender)	Superior 2	9	12	15
Ferrania	Superpanchro P.3	5	5½	6
	Superpanchro S.2	5½	6½	7½
Fuji	Neopan SS	6	8	14
Gevaert	Gevapan 27	7	10½	17
	Gevapan 30	5	6	8
	Gevapan 33	7	9½	12½
Hauff	Pancola	4½	6	8½
	Pancola Granex	6	8½	11
	Pancola Super	8	10½	14½
Ilford	F.P.3	7½	10	13
	H.P.3	4½	6	8
	H.P.S.	5	6½	8
	Pan F	5	7	9
Kodak (Canada)	Plus X	9	10½	13
	Super XX	14	16	19
	Tri-X	6	8	12
Kodak (Eastman Kodak)	Plus X	9	11	14
	Super XX	7½	9	12
	Tri-X	6	8½	12½
Kodak (France)	Panatomic X	3½	6	9
	Plus X	7	9	11½
	Super XX	10	13½	17½
Kodak (Great Britain)	Panatomic X	7	10	15
	Plus X	7	9	12
	Super XX	6	8	12
	Tri-X	6	8	12
Konishiroku	Sakura Konipan USS	7	11	17
Oriental	Oripan XF	8½	13	—
Perutz	Pergrano	3	5½	7½
	Peromnia	5½	7½	10
	Perpantic	5½	7½	10
Tensi	Beta 30°	3	4	5½

Sheet Films		Gamma		
		0·6	0·7	0·8
Adox	Filmpack 21	10	18	—
	PL 17	5½	9	13½
	PL 21 PM	5½	6½	8½
Ansco	Commercial	7	8½	10
	Commercial Ortho	7½	9	11
	Isopan	12	17	—
	Superpan Portrait	8	10½	13½
	Superpan Press	12½	16	20
	Triple S Ortho	18	26	—
	Triple S Pan	12½	16	19
Du Pont (Defender)	Commercial	7	9	12
	Fine Grain Pan	7	9	11
	High Speed Pan 428	11½	15	20
	X–F Ortho	16	24	—
	X–F Pan	13	18	26
Gevaert	Gevapan 30	7½	10	14
	Gevapan 33	9	15	22
	Gevachrome	8	10½	13½
Ilford	H.P.3	5	6	8
	H.P.S.	5½	7	8½
	Hyperchromatic	14	18	22
	Selochrome	11	14	18
Kodak (Australia)	Royal Pan	4	5½	7
	Super XX	5½	7½	9½
Kodak (Canada)	Royal Pan	5	6½	8½
	Super Panchro Press	14	17	20
	Super XX	10	12	15
	Tri-X	7	10	14½
Kodak (Eastman Kodak)	Portrait Pan	10	12	—
	Royal Pan	5½	7½	10½
	Super Ortho Press	6	8	10½
	Super Panchro Press –Type B	10	14	18
	Super XX	12	15	20
	Tri-X Pan	11	18	—
Kodak (Great Britain)	Commercial Ortho	7	10	12
	Ortho X	9½	11	14
	Panatomic X	10	13	20
	Panchro Royal	5	7	9½
	Super XX	10	13	20

AN ALTERNATIVE METHOD OF DEVELOPMENT

Instead of using 'Promicrol' at its standard concentration, as described on page 12, it is sometimes more convenient to dilute it further; two satisfactory methods of doing this are:

Where several films are to be developed successively. The developer is diluted to five times the volume of the tank available, and one-fifth of the total volume used for each of five films, the solution being discarded after use.

Where films are to be developed occasionally. 21 oz. (600 c.c.) of normal developer are divided into five equal parts (of $4\frac{1}{5}$ oz., or 120 c.c., each) and are stored in well-sealed small bottles, away from light. If properly sealed, the solution will keep satisfactorily for months, but it tends to oxidize more readily if diluted before storage. For use, the contents of one bottle are diluted to the volume of the tank available, and the solution is discarded after developing one film in it.

The development times for the normal solution will have to be multiplied by a factor if either of these methods is adopted; the factor is found in the following manner:

The total volume to which the 21 oz. (600 c.c.) of developer are to be diluted, and the gamma required, are decided; the corresponding factor is read from the table following, noting that some interpolation may be necessary. The normal development time (as found from pages 15 to 17) is multiplied by this factor, to give the appropriate time for this dilution method.

For example, if 21 oz. (600 c.c.) are diluted to 105 oz. (3 litres), and a gamma of 0·7 is required, the factor from the table is 3·1; the development time given on page 17 for Kodak Panatomic X (Miniature film) to a gamma of 0·7 is 10 minutes at 68°F or 20°C. Hence the development time in 21 oz. (600 c.c.) of the diluted developer to the same gamma is $10 \times 3{\cdot}1 = 31$ minutes.

Additional Volume of Water Added c.c.	Total Volume c.c.	Additional Volume of Water Added oz.	Total Volume oz.	% Increase in volume	Gamma		
					0·6	0·7	0·8
0	600	0	21	0	1·0	1·0	1·0
60	660	2	23	10	1·1	1·1	1·1
120	720	4	25	20	1·2	1·2	1·2
180	780	6	27	30	1·3	1·3	1·3
240	840	8	29	40	1·3	1·4	1·4
300	900	10	31	50	1·4	1·4	1·4
450	1050	15	36	75	1·5	1·6	1·6
600	1200	21	42	100	1·7	1·8	1·8
1200	1800	42	63	200	2·1	2·3	2·5
1800	2400	63	84	300	2·5	2·7	2·9
2400	3000	84	105	400	2·8	3·1	3·3
3000	3600	105	126	500	3·1	3·4	3·6
3600	4200	126	147	600	3·4	3·7	3·9

NOTES

1. By this dilution method, only one film is developed in any one part of the developer, and the solution is then discarded. The question of increasing the development time for a second film in the same solution does not arise.

2. The table has been constructed to allow for a variety of dilutions, up to seven times the original volume. Development times are apt to become unduly long at high dilutions, and a total volume of 105 oz. or 3 litres (i.e. five times the original volume) will be found generally satisfactory.

3. The factors quoted have been determined for tanks of the normal sizes for single films (7 to 21 oz., or 200 to 600 c.c.); they do not apply for bulk use, and if 21 oz. of 'Promicrol' are diluted to 105 oz. (600 c.c. to 3 litres), and the whole diluted solution used in a large tank, the appropriate development time may be as much as 20 per cent shorter than that calculated by the method described above.

4. All the above factors – and indeed all recommended development times – can give no more than a guide to the correct time to be used in any particular circumstances. Consistently satisfactory results demand consistent processing conditions, and the values quoted may require slight modification to suit individual preferences.

EXHAUSTION

The number of films which can be developed with a given quantity of 'Promicrol' depends upon many factors, such as the type of film employed, the overall negative densities obtained and the care with which developer oxidation is avoided (during preparation, use and storage), as well as the area of film processed. The following figures give a general indication of the capabilities of this developer, but individual circumstances may cause divergences from the figures quoted.

Film Number	Development Time (minutes)
1	10
2	11
3	12
4	13¼
5	14½
6	16
7	17½

The figures refer to 36-exposure lengths of 35 mm. film (each of which is equivalent in area to one No. 20 size roll film, or to two No. 27 size roll films) successively developed in 21 oz. (600 c.c.) of 'Promicrol' in a spiral tank. An initial development time of ten minutes is assumed; the corresponding figures for other initial development times can be found by direct proportion.

KEEPING PROPERTIES

The unused developer will keep for several months if stored in full bottles, closed with a rubber bung, away from light. The storage life of the used solution is naturally somewhat shorter, and depends upon the care taken in use and storage; under normal conditions, the developer will keep for two or three months, if used occasionally.

In common with many other fine-grain developers, particularly those of the silver-halide solvent type, a grey flocculent precipitate slowly forms in the used solution on standing, and frequently adheres to the sides of the container. This precipitate is essentially metallic silver, and if it becomes abundant it should be filtered off; its presence does not affect the developing properties of the solution.

REPLENISHER

The users of large quantities of 'Promicrol' will find its replenisher of great value in standardizing processing conditions. By adding replenisher solution to the developer at the appropriate rate, the development time to a given gamma remains constant throughout the whole life of the combination; the procedure to be used is thereby simplified and considerable economy is effected. When used correctly the replenisher causes no increase in graininess, nor any loss in the high emulsion speeds normally found with 'Promicrol'.

To prepare the solution, the contents of the smaller package are added to warm water (at about 100°F or 40°C), using about three-quarters of the total volume of water required. The vessel is stirred or shaken until most of the solid has dissolved, and the contents of the larger package are then added. Agitation is continued until solution is complete; the liquid is then diluted to the appropriate volume and stored in full closed bottles away from direct sunlight, if possible in the dark. The keeping properties of the replenisher are generally similar to those of 'Promicrol' developer, as given above.

Directions for use. With large tanks the most convenient method of replenishment is to add to the tank at the

start of each day's work sufficient replenisher to restore the liquid to its original level.

With smaller tanks it is preferable to calculate the rate of addition from the area processed and to add replenisher at convenient intervals at the rate of 1 oz. of replenisher solution per 80 sq. in. of film developed (55 c.c. per 1000 sq. cm.).

The exact rate of replenishment will vary with the individual technique used, and the above figures are therefore intended as a guide; circumstances may make some alteration necessary.

Correct replenishment will ensure constant highlight density for a standard development time throughout the life of the bath. It is important to protect the developer from aerial oxidation (e.g. by means of a floating lid) when it is not in use.

Exhaustion. When used as directed, 1 gallon of 'Promicrol' and ½ gallon of replenisher will develop about 45 sq. ft. of film i.e. about 80 No. 20 size films. 1 litre of 'Promicrol' solution and 0·5 litre of replenisher will develop about 1 sq. metre of film i.e., about 18 No. 20 size films.

The volume of replenisher which can be added to a given volume of 'Promicrol' before the whole is too exhausted for further use will depend upon the standard of constancy demanded by the operator. If this standard is very high then the volume of replenisher which can usefully be added is about half that of the original solution. Most users, however, are content with a less exacting standard, and have found that a volume of replenisher equal to that of the original developer may be used before any significant loss of quality can be seen in the results.

Special procedure for tropical climates

The development conditions recommended on page 12 are suitable only for temperatures between 59° and 75°F (15° and 24°C); if the developer is to be used above 75°F (24°C), as is frequently necessary in tropical countries, not only will the development times become inconveniently short, but the emulsions used will probably frill and may be completely removed from their support.

Both these difficulties are overcome by adding sodium sulphate to the solution before development, the quantity added being adjusted so that the development times and other characteristics are not significantly altered. Thus the development times of various emulsions in "sulphated" 'Promicrol' at 80°F (27°C) are substantially equal to those in the normal solution at 68°F (20°C).

PREPARATION OF THE DEVELOPING SOLUTION

The solution is prepared as directed in the instruction leaflet, and after dilution to volume, anhydrous sodium sulphate is added at the rate of 10 per cent (i.e. 1 lb. per gallon, or 60 grammes per 600 c.c. pack); the solution is shaken until all the sodium sulphate has dissolved, and is then ready for use.

Glauber's Salts (hydrated sodium sulphate) can be used instead of anhydrous sodium sulphate, if more convenient. The salts should be added at the rate of 22·5 per cent (i.e. 2·25 lb./gallon, or 135 grammes/600 c.c. pack); the developer chemicals should be dissolved in about five-sixths of the total volume of water required, the Glauber's Salts added, and dissolved by shaking or stirring. The solution is finally diluted to the required volume before use.

Exposure. This addition causes no alteration in the effective emulsion speed given by 'Promicrol'; the exposures selected should make full use of the enhanced emulsion speeds normally found with this developer.

Development. The development times using the sulphated developer at 80°F (27°C) are substantially equal to those recommended for the normal developer at 68°F (20°C). For development times at temperatures other

than 80°F (27°C), the times quoted for 68°F (20°C), should be multiplied by the factor shown below, to give the appropriate times in the sulphated developer.

Temperature		Factor	Temperature		Factor
°F	°C		°F	°C	
75	24	1·5	81	—	0·95
77	25	1·3	—	28	0·85
79	26	1·1	84	29	0·75
80	27	1·0	85	—	0·70

Thus, if a development time of 10 minutes/68°F or 20°C is satisfactory for the normal developer, then the sulphated developer will need 10 minutes/80°F or 27°C, or 7½ minutes (i.e. 10×0·75) at 84°F or 29°C.

Stopbath. A stopbath should be used before fixation, to avoid contamination of the fixing solution with developer; it is particularly important to do so if one of the rapid hardening fixers, such as 'Amfix', is being used.

The stopbath recommended is:

Acetic acid, glacial	3 parts
Sodium sulphate anhydrous	5 parts
Water	to 100

Developed films should be soaked in this solution for two minutes before transfer to the fixer; if a stopbath without sodium sulphate is used, reticulation or frilling will probably occur. The stopbath should be replaced before it becomes alkaline.

Fixation. It is important to use an efficient hardening and fixing solution, such as 'Amfix', but there is no need to load this with sodium sulphate. Immersion of films in this solution should be long enough to ensure that not only is fixation complete, but sufficient time has been allowed for the hardening to be effective. Three times the clearing time will be adequate for a normal solution.

NOTES

1. It is important to note that the addition of anhydrous sodium SULPHATE (Na_2SO_4) is involved, not that of anhydrous sodium sulphite (Na_2SO_3).

2. The effect of the addition is satisfactory only if ALL the processing solutions are kept at the same temperature; the maximum divergency permissible is $\pm$ 5°F (3°C).

3. The normal film characteristics – emulsion speed, graininess, contrast, etc. – are substantially unaltered if films are processed as recommended. The characteristic curves, and time-gamma curves, available for various emulsions in 'Promicrol' at 68°F (20°C) may therefore be used, without significant error, for the treated developer at 80°F (27°C).

4. In certain circumstances, it may be more convenient to modify the sodium sulphate content of the developer, rather than the development time; 'Promicrol' solution containing 6 per cent of anhydrous sodium sulphate requires the same development times at 75°F (24°C) as the untreated developer at 68°F (20°C). 'Promicrol' solution containing 12 per cent of anhydrous sodium sulphate requires the same development times at 85°F (29°C), as the untreated developer at 68°F (20°C).

5. The use of 'Promicrol' at temperatures above 85°F (29°C) is not recommended.

Technical Data

EMULSION SPEED

It is well known that under-exposure of an emulsion causes lack of shadow detail in the processed negatives, and this frequent fault leads to dark unrelieved areas appearing on the prints. 'Promicrol' possesses the very valuable property of emphasizing shadow-detail without adversely affecting the other tones; consequently the errors of under-exposure can be minimized by processing in 'Promicrol', and satisfactory negatives obtained using a shorter exposure than the minimum recommended by the emulsion manufacturer.

'Promicrol' has, therefore, the property of increasing effective emulsion speed, but the extent of this increase depends upon a variety of factors. Of these, the most important is the method employed to measure emulsion speed. From the argument above, it would be expected that methods based upon measurements in the "region of under-exposure" would indicate an increased speed with 'Promicrol', but those based upon the whole straight line portion would not indicate this increase.

This expectation is borne out by experiment; speed measurements based on the classical method of Hurter and Driffield show that 'Promicrol' causes a slight loss of emulsion speed, of about 10 per cent of the normal maximum (this loss is so small as to be negligible in practice). By using other methods, such as the D.I.N. or the British Standard (useful gradient) method, an increase in speed is found, to values considerably above the normal maxima.

The extent of this increase in speed depends upon the emulsion used, and the gamma to which it is developed. It is therefore not possible to list the speed increases without specifying the processing conditions. However, many photographers have found that the minimum permissible

exposures with normal developers may be halved if 'Promicrol' is used; adequately exposed negatives are obtained from which prints of the highest quality can be made. It is often possible to divide the normal minimum exposure by three for some emulsions, and still to ensure first-class print quality.

It has long been known that many negative developers will give significant increases in speed if some slight decrease in the quality of the final print can be tolerated. Under-exposure followed by over-development can yield negatives from which quite satisfactory prints can be made, and speeds four, six or even eight times normal can be obtained. The maximum speed increase found depends very largely upon the extent of tonal distortion permissible, that is, the extent of loss of print quality that can be tolerated. Moreover, the technique is only of value if the subject is low in contrast.

'Promicrol' is no exception to this general rule; by adjusting the conditions of exposure and development, it can be used to give acceptable prints from negatives which have been under-exposed by eight times. The property which makes 'Promicrol' unique among developers is its ability to increase film speeds two or three times, by orthodox photographic methods using the current British Standard method of measuring film speed; the negatives are developed to gammas about 0·7, so that prints of the highest possible quality are obtained.

It should therefore be obvious that the extent to which exposure may be curtailed when 'Promicrol' is to be used is a matter for personal experiment and decision. Until some familiarity with the product has been obtained, it is recommended that the exposures found from meter readings or tables should be halved, and the development time for a gamma of 0·7 used. When some experience has been gained in the orthodox technique, users may be inclined to experiment with the under-exposure over-development method – with the knowledge that a further doubling or trebling of the speed will be accompanied by a perceptible, though not prohibitive, loss of print quality.

The result of a few speed measurements, made by the H & D and Useful Gradient methods, are given in the table in the next section.

GRAININESS

Comparative measurements were made on densities of 0·30, which had been developed to a gamma of 0·80 in various developers. The method employed was based on that described by Jones and Deisch (*J. Franklin Inst.*, 1920, **190**, 657), in which the density specimens were examined at varying distances until the graininess just seemed to disappear. The distances were measured and expressed relative to that for a *p*-phenylenediamine developer, to which was given the arbitrary value of 100; these relative distances gave graininess indices for the developers used. The *p*-phenylenediamine formula (known as "Sease 1") is believed to give the minimum graininess attainable, and Developer A (for formula see below) gives the normally accepted maximum emulsion speed. Developer B (see below) is a typical fine-grain developer of the "solvent" type. The last column gives the ratio of effective emulsion speed to graininess index; the higher this ratio, the closer the developer approaches the ideal.

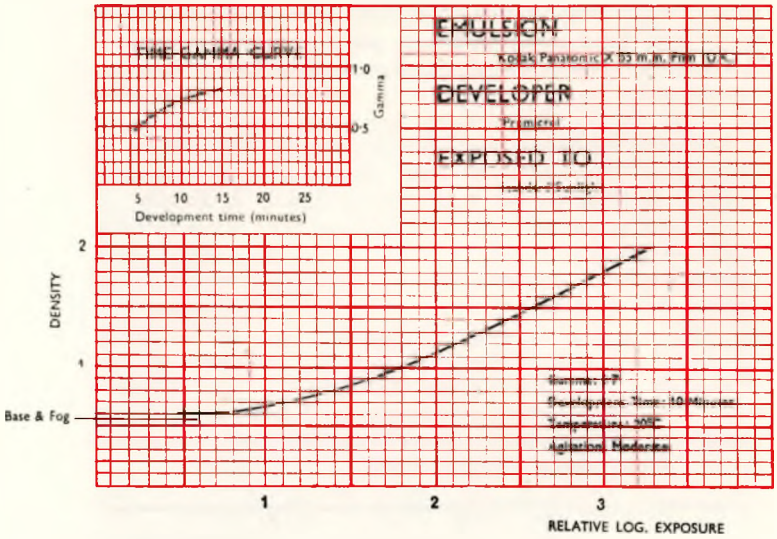
Developer	Graininess	Emulsion Speed		Emulsion Speed / Graininess	
		H & D Method	*Useful Gradient Method*	*H & D Method*	*Useful Gradient Method*
'Promicrol'	115	90	200	0·78	1·74
Developer A	175	100	100	0·57	0·57
Developer B	140	67	71	0·48	0·51
p-Phenylenediamine	100	33	35	0·33	0·35

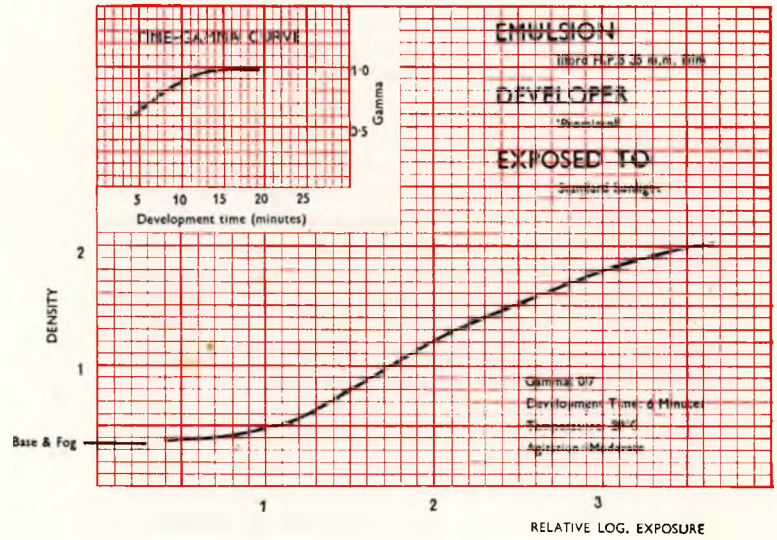
FORMULAE

	Developer A	B
Metol	0·2	0·5
Sodium sulphite (anhydrous) ..	10	10
Hydroquinone	0·5	—
Borax	0·2	—
Sodium metaborate	—	0·2
Potassium thiocyanate	—	0·1

Figures are in parts to make 100 parts of solution.

Development Characteristic Curves





CHARACTERISTIC CURVES

Characteristic curves (to standard sunlight) showing the relationship between density and log. exposure have been obtained for a wide variety of emulsions developed in 'Promicrol'; some typical examples are given on the opposite page and copies of curves for many other emulsions can be obtained on application. These curves were all obtained under standard conditions, viz. development to a gamma of 0·70 at 68°F (20°C) with moderate agitation in a tank, using fresh 'Promicrol' solution. In order that they may relate to printing densities, the values given have not been corrected for fog or base density.

Time-gamma curves are also given, from which development times for gammas other than those quoted on pages 14 to 18, can be found.

EFFECT OF TEMPERATURE

All development times quoted have been determined at 68°F (20°C); if it is necessary to work at some other temperature, the development time must be altered accordingly.

The following table shows the relation between the development time and temperature for 'Promicrol', for the temperature range 60° to 76°F (16° to 24°C).

°F	Development Time in Minutes					°C	Development Time in Minutes				
60	4·8	8·4	12·0	14·4	18·0	16	4·7	8·3	11·8	14·2	17·7
62	4·6	8·1	11·5	13·8	17·3	17	4·5	7·9	11·4	13·6	17·0
64	4·4	7·7	11·0	13·2	16·5	18	4·4	7·6	10·9	13·1	16·4
66	4·2	7·4	10·5	12·6	15·8	19	4·2	7·3	10·5	12·5	15·7
68	**4·0**	**7·0**	**10·0**	**12·0**	**15·0**	**20**	**4·0**	**7·0**	**10·0**	**12·0**	**15·0**
70	3·8	6·7	9·5	11·4	14·3	21	3·8	6·7	9·6	11·5	14·3
72	3·6	6·3	9·0	10·8	13·5	22	3·6	6·4	9·1	10·9	13·7
74	3·4	6·0	8·5	10·2	12·8	23	3·5	6·1	8·7	10·4	13·0
76	3·2	5·6	8·0	9·6	12·0	24	3·3	5·7	8·2	9·8	12·4

For temperatures above those quoted in this table, *see* the Special Procedure for Tropical Climates on *pages* 24 to 26.

How to use this table. Determine from the tables on

pages 14 to 18 the correct time at 68°F (20°C) for the emulsion used and the gamma desired; if this is 4, 7, 10, 12, or 15 minutes, the corresponding development time at other suitable temperatures can be found directly in the table. If the development time found at 68°F (20°C) is not among the five times quoted, the desired time can be calculated by simple proportion.

NOTE. The times in the table have been quoted to the nearest tenth of a minute for convenience, but it is not necessary to work to this degree of precision during development, since accuracy to about ½ minute will suffice. Indeed, since the temperature coefficient of a developer is sometimes affected by the emulsion used, these figures are the averages for a variety of films, and hence must be regarded only as a guide.

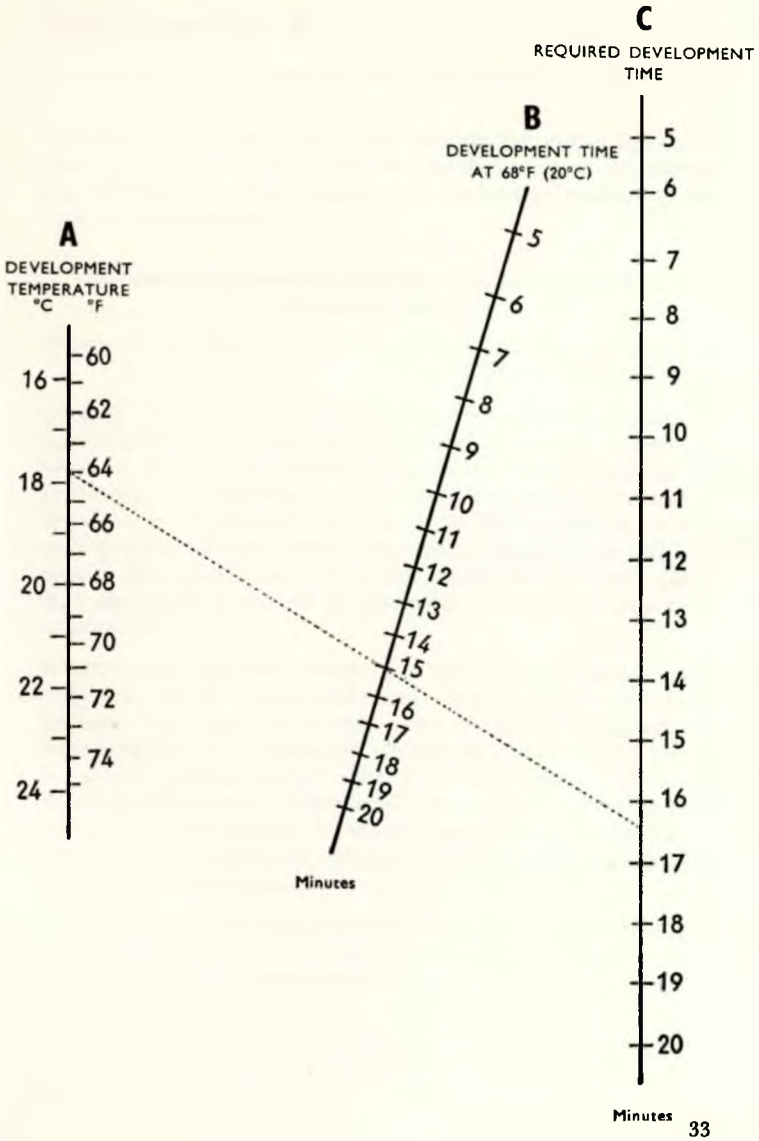
On page 33 is a nomograph which enables development times to be found rapidly without calculation; it is used in the following manner:

1. Select from the Development Time Table on pages 14 to 18 the time at 68°F (20°C) appropriate for the emulsion used and the gamma sought.
2. Locate the temperature of working on Scale A, and the development time at 68°F (20°C) found on Scale B.
3. Join these two points on scales A and B by a straight line and continue this line to cut scale C; the time corresponding to the intersection of this line with scale C is the development time for the temperature of working.

An example will make this clear; from the table on page 17 the development time for Panatomic X miniature film to a gamma of 0·8 is 15 minutes at 68°F. To find the development time to this gamma at 64°F three steps are necessary:

1. Locate the temperature 64°F on the scale A, as shown.
2. Locate the time 15 minutes on scale B.
3. Join these two points, as shown by the dotted line, and continue this line to cut the scale C. The intersection corresponds to 16½ minutes, and this is the required development time at 64°F.

A Development Time Nomograph for 'Promicrol'



Appendix I

'Promicrol' has been used with success for many applications of photography in science, medicine, and industry; the following abstract describes a technique employed in medical radiography.

Reducing Exposures in Indirect Radiography (Fluorography)

Silver, P. S., Hills, T. H., and Stanford, R. W. (1953), *Brit. J. Radiol.*, **XXVI,** 136.

Abstract. The medical use of miniature and semi-miniature methods of fluorography has increased with every improvement in the optical systems, fluorescent screens and films available, but has remained limited because the exposure required is considerably in excess of that given in direct radiography. These heavy exposures involve the risk of overloading the X-ray tube and contradict the principle that the patient should be exposed to as little radiation as possible.

A technique has been evolved which enables satisfactory negatives to be produced from films given exposures between 0·2 and 0·6 times that normally required in fluorography, i.e., exposures comparable with those given in direct radiography. The "under-exposed" film is developed in used 'Promicrol' artificially aged by the addition of potassium bromide; prolonged development then gives negatives of adequate density range, while the fog level remains low.

It is suggested that this technique may prove to be of value in cineradiography, in chest radiography with 35 mm. film, and in angiocardiography.

Names quoted thus 'Promicrol' are trade marks, the property of May & Baker Ltd, indicating their brand of the preparations.

'PROMICROL'

Supplied in containers to make:

600 c.c.
2½ litres
13½ litres
20 litres

REPLENISHER FOR 'PROMICROL'

Supplied in containers to make:

2½ litres
10 litres

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